Atomic Energy Control Board
P.O. Box 1046
Ottawa, Canada
K1P 5S9

Commission de contrôle de l'énergie atomique
C.P. 1046
Ottawa, Canada
K1P 5S9

INFO-0134

COOPERATIVE DEVELOPMENT OF NUCLEAR SAFETY REGULATIONS, GUIDES AND STANDARDS BASED ON NUSS

by

J. Pachner, F.C. Boyd
Atomic Energy Control Board
Ottawa, Canada

E.M. Yaremy
Atomic Energy of Canada Limited
Mississauga, Ontario

PAPER

October 29, 1984

Résumé

Le présent rapport traite d'un des principaux besoins des États membres en voie de développement qui construisent des centrales nucléaires d'origine étrangère, soit l'acquisition des moyens leur permettant d'assurer la réglementation autonome de telles centrales. À cette fin, il est nécessaire d'élaborer des normes, des guides et des règlements nationaux de sûreté nucléaire pour contrôler la mise au point et l'utilisation des techniques nucléaires. Étant donné l'importance et la complexité d'un tel travail, il faudrait que les États membres exportateurs de centrales nucléaires partagent leur expérience et collaborent avec les États membres importateurs dans l'élaboration des règlements et des guides nationaux.

En 1983, la CCEA et L'EACL ont mené une étude relative à un programme conjoint possible entre le Canada, un État membre importateur et l'AIEA, dans le but de mettre au point des règlements et des guides nationaux de sûreté nucléaire, basés sur les documents du Programme sur les normes de sûreté nucléaire (NUSS). Au cours de l'étude, on a élaboré, comme exercice préliminaire, un plan de travail qui comprenait une évaluation de la main-d'oeuvre nécessaire à l'élaboration des règlements relatifs à la conception, des guides de sûreté et d'un guide d'évaluation réglementaire de la conception. D'après le plan de travail, il faudra que des ressources importantes soient disponibles au début du programme conjoint afin de permettre une mise en oeuvre efficace du Programme sur les normes de sûreté nucléaire dans les États membres en voie de développement.

En outre, l'étude a montré qu'un tel programme conjoint pourrait servir de moyen efficace pour transmettre des connaissances en sûreté nucléaire aux États membres en voie de développement, grâce à la mise en oeuvre du Programme sur les normes de sûreté nucléaire.

COOPERATIVE DEVELOPMENT OF NUCLEAR SAFETY REGULATIONS, GUIDES AND STANDARDS BASED ON NUSS

Paper presented at the International Symposium on Safety Codes and Guides (NUSS) in the Light of Current Safety Issues, Vienna, Austria, 29 October-2 November 1984

Abstract

A major need of developing Member States building nuclear power plants (NPP) of foreign origin is to acquire a capability to regulate such nuclear plants independently. Among other things, this requires the development of national nuclear safety regulations, guides and standards to govern the development and use of nuclear technology. Recognizing the importance and complexity of this task, it seems appropriate that the NPP-exporting Member States share their experience and assist the NPP-importing Member States in the development of their national regulations and guides.

In 1983, the Atomic Energy Control Board and Atomic Energy of Canada Limited conducted a study of a possible joint program involving Canada, an NPP-importing Member State and the IAEA for the development of the national nuclear safety regulations and guides based on NUSS documents. During the study, a work plan with manpower estimates for the development of design regulations, safety guides and a guide for regulatory evaluation of design was prepared as an investigatory exercise. The work plan suggests that a successful NUSS implementation in developing Member States will require availability of significant resources at the start of the program.

The study showed that such a joint program could provide an effective mechanism for transfer of nuclear safety know-how to the developing Member States through NUSS implementation.

1. INTRODUCTION

An important goal of a Member State embarking on a nuclear power program is to develop an indigenous capability to regulate nuclear power plants in order to ensure an acceptable level of safety in their operation. Nuclear safety regulations, guides and standards (in this paper commonly called nuclear safety standards) establish what is an adequate level of safety and thus constitute a vital element in the development of nuclear power. Consequently an important objective which must be accomplished in order to achieve the above goal is to develop national nuclear safety standards.

The development of national nuclear safety standards is a difficult task for any Member State, especially a developing Member State, and requires the work of experienced engineers and scientists. One way of accomplishing this objective within a reasonable time period is to pool the resources of the NPP-importing Member State, the NPP-exporting Member State, and the International Atomic Energy Agency (IAEA) in a joint program for the development of national nuclear safety standards based on Nuclear Safety Standards (NUSS) Codes and Guides.

This paper presents a possible concept for such a joint program derived from a study which was conducted by the Atomic Energy Control Board (AECB) and Atomic Energy of Canada Limited (AECL) in 1983. Section 2 of the paper gives reasons for using the NUSS documents as a basis for the development of national nuclear safety standards. Section 3 suggests a hierarchy of the nuclear safety standards and of the corresponding NUSS documents. Section 4 describes a possible joint program in some detail, and finally, Section 5 gives conclusions.

2. NUSS DOCUMENTS AS A BASIS FOR NATIONAL NUCLEAR SAFETY STANDARDS

Nuclear safety standards should specify principal safety requirements and performance objectives which have to be satisfied in order to achieve an adequate level of safety.

There are several reasons for proposing NUSS documents as the basis for developing national standards. These reasons have been mentioned in various papers referring to NUSS and its implementation, and in other papers of this symposium. However, to highlight them in the context of a program such as described in this paper, the most relevant ones are given below.

NUSS codes and guides are based on the cumulative experience of Member States, and represent a synthesis of the best or most common practices. They take into account both the different approaches to achieving nuclear safety followed in various states, and the several designs of nuclear power plants which are being built and operated in Member States. Since the NUSS documents are based on a broad consensus of Member States, they provide an internationally based frame of reference for the development of national nuclear safety standards, especially for a state having, or intending to have, more than one type of nuclear power plant.

Because of their nature, the NUSS documents cannot be ignored by any state developing new safety requirements or by any company exporting nuclear power plants to developing states. Also, through the use of NUSS documents, it is possible for a regulatory body of an NPP-importing Member State to require that different types of plants satisfy common safety principles.

Developing Member States can use NUSS documents in three basic ways:

(1) adopt the documents as they are into the national system of nuclear safety standards

(2) adapt the documents to suit the particular nation's situation

(3) use the documents as source documents for developing national documents.

The most appropriate use of the NUSS documents will have to be determined on a case-by-case basis. It will depend on the Member State's particular situation (e.g. the extent to which the national nuclear safety standards have been developed, the legal framework and the structure of its nuclear industry), and on the particular NUSS documents to be used. Some NUSS documents (e.g. QA series) are specific enough to enable their direct adoption as national standards, while other NUSS documents (e.g. Design series) are expressed in a more general form to accommodate all types of thermal nuclear power plants and will require interpretation for a particular reactor type by experienced engineers and scientists.

3. HIERARCHY OF NUCLEAR SAFETY STANDARDS

When judging the applicability of NUSS documents for the development of national nuclear safety standards, it is important to place them at the right level or tier within the hierarchy of the standards. In this context the following hierarchy of the nuclear safety standards is suggested:

National Documents	**NUSS Documents**
(1) Nuclear Law - A law which usually provides the legal basis for control of nuclear activities of a state by a regulatory body established under this law.	50-C-G - This Code of Practice gives recommendations for the structure and operation of the regulatory body, and guidance for the basic nuclear legislation.
(2) General Safety Objectives and Criteria - A statement of objectives underlying regulation of nuclear activities, and general means of achieving the objectives.	No single NUSS document applicable.

(3) Nuclear Safety Regulations - Regulatory requirements issued under the Nuclear Law which must be satisfied by all users of nuclear materials and facilitiies. (In some states the Regulations contain primarily administrative requirements, while technical requirements such as those in NUSS Codes are included in other regulatory documents which must be satisfied by the applicant/licensee).	Codes of Practice - A compilation of fundamental nuclear safety principles, objectives, and minimum requirements which must be fulfilled to provide an adequate level of safety.
(4) Safety Guides - Recommended practices for meeting the regulatory requirements. (In some states these guides are issued by the design organization rather than the regulatory body.)	Safety Guides - Information and recommendations on implementing the fundamental safety principles and fulfilling the minimum requirements of the Codes.
(5) Industrial Standards - Detailed standards such as ASME, DIN or CSA standards* to be satisfied by the NPP structures, systems and components.	No NUSS guidelines on preparation of national industrial standards exist.

4. JOINT PROGRAM FOR THE DEVELOPMENT OF NATIONAL NUCLEAR SAFETY STANDARDS

The envisaged joint program involves three participating parties: an NPP-importing Member State (IMS), an NPP-exporting Member State (EMS), and the IAEA. The program's goal is to develop a national system of nuclear safety standards based on NUSS. Its scope and objectives must be determined on a case-by-case basis depending on the specific situation (e.g. state of the national nuclear power program) of the NPP-importing Member State.

For the purpose of this paper, the following assumptions are made:

- The Nuclear Law of the importing Member State has been promulgated.
- The IMS communicates to the EMS and IAEA its interest in a joint program for the development of national nuclear safety standards and appoints its Project Coordinator.

---

* ASME - American Society of Mechanical Engineers
DIM - Deutsche Industrie-Normen
CSA - Canadian Standards Association

- The EMS and the IAEA agree in principle and appoint their respective Project Coordinators.

4.1 PHASE I - Program Planning and Approval

In this phase the scope and feasibility of the joint program should be determined, and resources required for the program implementation should be approved. Phase I objective is stated below.

> **Objective of Phase I:** To define the program objectives (i.e., desired results within specific time and resources), to prepare a work plan for achieving the objectives, and to obtain necessary approvals from the parties involved to permit the implementation of the program.

The Project Coordinators appointed by the three parties would communicate with each other to facilitate implementation of Phase I, and if approved, of Phase II as well.

To accomplish the objective it is suggested that a Joint Task Force (JTF) be formed whose role would be to prepare the program objectives, to detail a plan of work, and to estimate resource requirements. The JTF should be composed of middle managers representing both the regulatory body and nuclear industry, and having two members from the IMS, two from the EMS, and one from the IAEA. The JTF would report to the Joint Oversight Group (JOG) whose role would be to review and approve the joint program. The JOG composition is recommended to be the same as for the JTF, but at a senior management level.

Various activities of the Phase I, and time estimates for the recommended participants are shown in Fig. 1. After approval of the program by the JOG, the JTF would complete Phase I by refining the work plan taking into account views of the JOG, and by identifying working groups whose role would be the actual development of the standards. Experts from both the regulatory body and nuclear industry should participate in the development of the standards to promote mutual understanding between the regulatory and licensee staffs and thus discourage any unproductive adversarial relationship.

Phase I is expected to extend over approximately 8 months.

A sample work plan developed during the 1983 AECB/AECL study forms the basis for the discussion of Phase II in the next Section.

4.2 PHASE II - Program Implementation

Since the 1983 AECB/AECL study of the possible joint program was limited to the area of design, the sample work plan derived from that study has the same limitation. However, it illustrates sufficiently the suggested approach and corresponding manpower requirements.

The area of design was selected as a subject of the study because the primary safety of an NPP depends on the design. Furthermore, the NUSS design documents require probably the greatest amount of explanation, interpretation or augmentation because they cover all major thermal neutron reactor types. They contain the basic safety requirements and their implementation requires the work of experienced engineers and scientists. Also, the development of national nuclear safety standards in the design area would provide an opportunity for the transfer of know-how needed at other stages of the national nuclear power program, e.g., safe operation and maintenance of an NPP must be based on thorough understanding of the design.

The work plan does not include a development of industrial standards. However, pertinent national and international standards would be referenced in the Safety Guides.

The objective of the program envisaged in the AECB/AECL study can be expressed as follows.

> **Program Objective:** To prepare national regulations, safety guides and a guide to regulatory evaluation of design within two-and-a-half-years, based on the Design section of NUSS Codes and Guides and consistent with the national General Safety Objectives and Criteria (to be developed as a first step of the work plan).

To accomplish the Program Objective in an effective way four subordinate objectives were identified. These objectives and respective work plans for their achievement are discussed in the following subsections.

The overall schedule of Phase II, showing the major activities corresponding to the subordinate objectives, is presented in Fig. 2. The program implementation would involve three groups with different but complementary roles. Ongoing program management and facilitation would be provided by the Project Coordinators. The Joint Oversight Group would monitor progress and initiate program changes, if needed, to achieve the program objectives, while the actual work, i.e. standards development, would be done by the working groups. A flowchart of planned activities by the working groups is shown in Fig. 3.

4.2.1 General Safety Objectives and Criteria

> **Subordinate Objective No. 1:** To prepare General Safety Objectives and Criteria to guide the development of national nuclear safety standards.

A properly structured development of national nuclear safety standards requires that the underlying nuclear safety objectives and general means of achieving them are established at first. These General Safety Objectives and Criteria are placed at the second level in the hierarchy of the national documents discussed in Section 3, above the regulations, safety guides, and industrial standards.

The General Safety Objectives and Criteria would govern or guide the interpretation of the NUSS Codes and Guides, assuring that the rules derived from NUSS do fit the context of the national nuclear safety requirements.

Because the NUSS documents evolved as a synthesis of approaches followed by the IAEA Member States, there is no consolidated statement of the underlying principles.* In Canada the AECB endorsed, in 1982, a statement of safety objectives[1] prepared by its Advisory Committee on Nuclear Safety. This statement is the most recent expression of objectives that have been understood and pursued over the years[2,3]. Several other Member States have published similar documents. These expressions of principles and objectives could serve as a guide for the development of the General Safety Objectives and Criteria of the NPP-importing Member State.

Since no single NUSS document can serve as a reference for the task, it is proposed in the following work plan that the exporting Member State first prepares a draft proposal based on its own and international experience. The proposal would then be reviewed by the IMS, and finally revised by the joint working group as necessary to satisfy the national requirements.

In the manpower estimates given below the term senior person means a person with extensive nuclear experience and likely to be at a middle-management level. Senior technical level refers to persons with lesser but still significant nuclear experience.

Activity	Duration (month)	Manpower (man-month)
1.1 Prepare a draft proposal for the IMS General Safety Objectives and Criteria	1	EMS: 2 senior persons (2)
1.2 Review the draft proposal	1	IMS: 2 senior persons (2)
1.3 Jointly review and revise (if necessary) the draft	1	EMS: 2 senior persons (1) IMS: 2 senior persons (1) IAEA: 1 person (0.5)

4.2.2 **Regulations for Design of Nuclear Power Plants**

Subordinate Objective No. 2: To prepare national regulations or equivalent regulatory requirements for design of nuclear power plants based on the NUSS Design Code of Practice 50-C-D and the Guide 50-SG-D11.

---

* Safety Guide 50-SG-D11 will address general design safety principles for nuclear power plants. Reference 4 is an unofficial compilation of the most important principles underlying the NUSS documents.

It is proposed that regulations for design be divided into two parts:

Part A - Design Requirements
Part B - Requirements for Safety Analyses

As identified above the primary resource documents to be used in this task are:

- The Code 50-C-D, which contains the requirements for safe design of NPPs, and

- The Guide 50-SG-D11, which describes the defence-in-depth approach both from a functional and a multibarrier concept, and various methods of safety analysis.

In the work plan given below, it is proposed that the EMS interprets and augments the NUSS documents to meet the needs identified by the IMS, using its own extensive experience. An attempt should be made to maintain the generic nature of the requirements, but recognizing that the selected reactor type will influence to a certain degree some requirements and their interpretation. This applies to the development of national nuclear safety standards based on NUSS in general. One of the main roles of the IAEA participants in the joint working groups would be to ensure that the essence of the NUSS documents is retained.

The Requirements for Safety Analyses should cover the selection of postulated initiating events to be analyzed for the selected NPP, as well as general principles and guidelines relating to critical factors such as assumptions, experimental validation of models, and sensitivity analysis, which must be considered in the licensing submissions. Since none of the NUSS documents deals specifically with the subject of requirements for safety analyses, it is proposed that, similar to the work plan for the General Safety Objectives and Criteria, the EMS first prepares a draft proposal of the requirements (based on its own and international experience) for subsequent consideration by the IMS and the joint working group.

Following is the work plan for preparation of the Design Regulations.

Activity	**Duration (month)**	**Manpower (man-month)**
A. Design Requirements		
2.1 Review/interpret/augment 50-C-D and 50-SG-D11 for IMS use	6	EMS: Senior technical level (4-6)
2.2 Review 50-C-D and 50-SG-D11 and identify sections/paragraphs which need interpretation/ augmentation for the IMS use	2	IMS: Senior technical level (2-3)

2.3 Jointly review the draft Design Requirements and revise as necessary	1-2	EMS: 2 senior persons (2) IMS: 2 senior persons (2) IAEA: 1 person (1)

B. Requirements for Safety Analyses

2.4 Prepare a draft	9	EMS: Senior technical level (10-16)
2.5 Review a draft	2	IMS: Senior technical level (4)
2.6 Jointly review and revise (as necessary) the draft	1	EMS: 2 senior persons (1) IMS: 2 senior persons (1) IAEA: 1 person (0.5)

4.2.3 **Safety Guides for Design of Nuclear Power Plants**

Subordinate Objective No. 3: To prepare national safety guides for design of nuclear power plants based on NUSS Design Safety Guides 50-SG-D series.

The NUSS Design Safety Guides, which are the primary resource materials, describe in some detail the acceptable ways of implementing the requirements of the Code. In some exporting Member States these design recommendations are issued as regulatory requirements or guidelines to be satisfied by the designer. In other exporting Member States the designer has the responsibility to establish the details of the design and to demonstrate to the regulatory body that the design will meet the mandatory regulatory requirements. While it can be argued that the second approach is more desirable because it gives the designer more freedom for innovation and improvements in safety, one has to recognize the value of fairly detailed Safety Guides to the NPP-importing Member States not having sufficient experience to judge the acceptability of different design options.

The following work plan suggests that the EMS interprets and augments the NUSS design Safety Guides according to the needs identified by the IMS. Furthermore, appropriate industrial standards to be satisfied by the NPP should be referenced. It is expected that close interaction between the IMS, the EMS and the IAEA participants during the Safety Guides development will lead to much desirable transfer of nuclear safety know-how to the IMS.

Activity	**Duration (month)**	**Manpower (man-month)**
3.1 Review/interpret/augment NUSS Design Safety Guides for IMS use (appropriate industry standards for NPP design to be referenced)	7	EMS: Senior technical level (26-33)

Activity	Duration (month)	Manpower (man-month)
3.2 Review NUSS Design Safety Guides and identify sections/ paragraphs which need interpretation/augmentation for the IMS use	4	IMS: 2 senior persons (6-12)
3.3 Jointly review NUSS Design Safety Guides, and draft the IMS Safety Guides for design	6	EMS: 2 senior persons (6-12) IMS: 2 senior persons (6-12) IAEA: 1 person (3-6)

4.2.4 **Guide for Regulatory Evaluation of Design**

Subordinate Objective No. 4: To prepare national Guide for Regulatory Evaluation of Design that is to satisfy the IMS Regulations and Safety Guides for design of NPPs; to be based on the EMS, IMS and international experience.

The proposed Guide for Regulatory Evaluation of Design should provide a framework for a systematic assessment of the design and the supporting licensing submissions, and thus give the regulatory body assurance that the regulatory requirements and design objectives are actually met.

Activity	Duration (month)	Manpower (man-month)
4.1 Draft the Guide for Regulatory Evaluation of Design	6	EMS: Senior technical level (15-19)
4.2 Review the draft Guide	2	IMS: Senior technical level (4)
4.3 Jointly review and revise (as necessary) the draft Guide	3	EMS: 2 senior persons (6) IMS: 2 senior persons (6) IAEA: 1 person (3)

4.2.5 **Summary of Manpower Estimates for the Program Implementation**

The purpose of giving the above manpower and time estimates is to give some idea of the resources needed for a joint program of national nuclear safety standards (NNSS) development. It should be noted that since the discussed joint program has not been undertaken, there is no direct experience to support the estimates. The given estimates are based on some experience in the development of Canadian nuclear safety standards, but may be optimistic. The actual time and manpower needs will depend to a certain extent on the partners involved in the joint program, and the mutual relationship they will develop.

Estimates of the required manpower (in man-months) of the experts participating in the standards development as members of various working groups are summarized in the table below. Manpower estimates for the Project Coordinators and members of the Joint Oversight Group are not included.

TABLE 1. SUMMARY OF MANPOWER ESTIMATES FOR NUSS DEVELOPMENT

	Year 1			Year 2			Year 3		
	STL	MML	Total	STL	MML	Total	STL	MML	Total
IMS	2-3	5	7-8	16	6-11	22-27	4	7-8	11-12
EMS	14-22	5	19-27	39-49	6-11	45-60	3	7-8	10-11
IAEA			2			3-6			4

STL = Senior Technical Level
MML = Middle Management Level

The above estimates indicate a need for significant resources for the implementation of the program, a total of 10 to 13 man-years of appropriate subject matter experts. In addition to the time of the experts the joint program would involve considerable travelling expenses. One possible way of providing the necessary resources would be to implement the program as a multi-year project under the IAEA Technical Cooperation program. Under such a scheme the IAEA would cover the travelling expenses of the participants, but not necessarily their salaries.

5. CONCLUSIONS

National nuclear safety standards play an important role in achieving an adequate level of safety in the operation of nuclear power plants. Experience shows that their development is a complex and demanding task which requires knowledge of existing standards and specific national requirements, and considerable practical experience. In order to accomplish this task within a reasonable period of time, it is suggested that the importing Member State combines its resources with those of the IAEA and the exporting Member State in developing national standards based upon the IAEA nuclear safety standards.

The following conclusions pertinent to the development of national nuclear safety standards have been made:

1. NUSS documents provide a sound basis for the development of national nuclear safety standards.

2. The outlined joint program could provide an effective mechanism for transfer of nuclear safety know-how to a developing Member State needed at all stages of the state's nuclear power program.

3. Significant resources are required for the implementation of such a program.

4. Consideration should be given to funding the program by the IAEA under its Technical Assistance and Cooperation Program.

REFERENCES

[1] ACNS-2, A Proposed Statement on Safety Objectives for Nuclear Activities in Canada, a report by the Advisory Committee on Nuclear Safety of the Atomic Energy Control Board of Canada (1981).

[2] SIDDALL, E., Reactor Safety Standards and Their Attainment, AECL-498, Atomic Energy of Canada Ltd. (1957).

[3] HURST, D.G. and BOYD, F.C., Reactor Licensing and Safety Requirements, AECB-1059, Atomic Energy Control Board (1972).

[4] HURST, D.G., Safety Principles Underlying the NUSS Documents, IAEA Bulletin 22 (1980) 51.

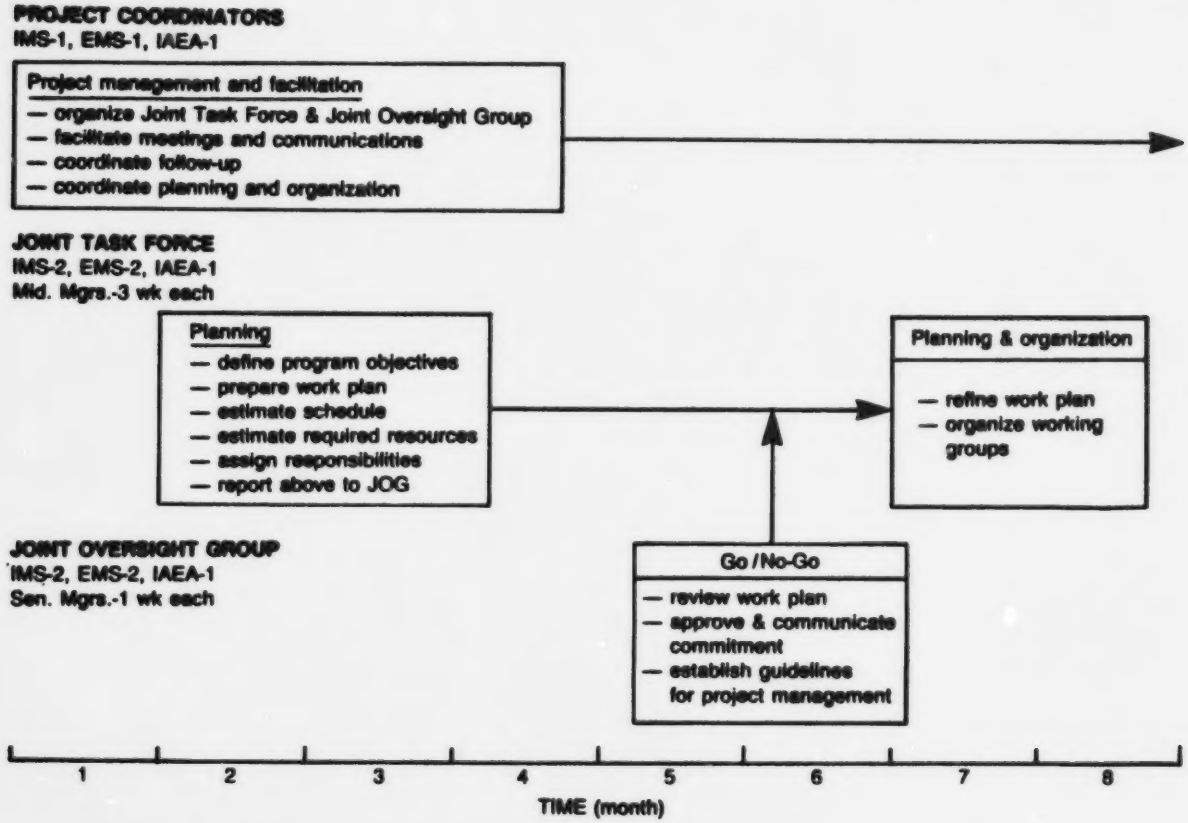

FIGURE 1 PHASE I — PROGRAM PLANNING & APPROVAL

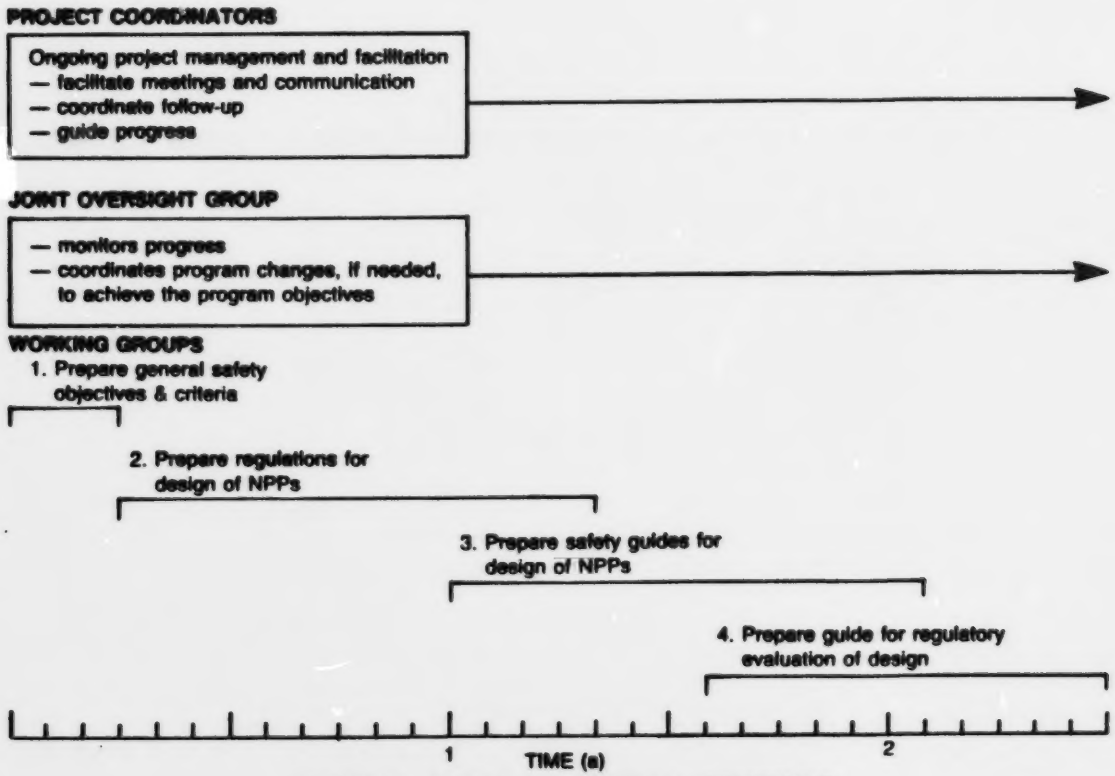
PROJECT COORDINATORS
Ongoing project management and facilitation
— facilitate meetings and communication
— coordinate follow-up
— guide progress
JOINT OVERSIGHT GROUP
— monitors progress
— coordinates program changes, if needed, to achieve the program objectives
WORKING GROUPS
1. Prepare general safety objectives & criteria
2. Prepare regulations for design of NPPs
3. Prepare safety guides for design of NPPs
4. Prepare guide for regulatory evaluation of design
1
2
TIME (a)

FIGURE 2 PHASE II — OVERALL SCHEDULE

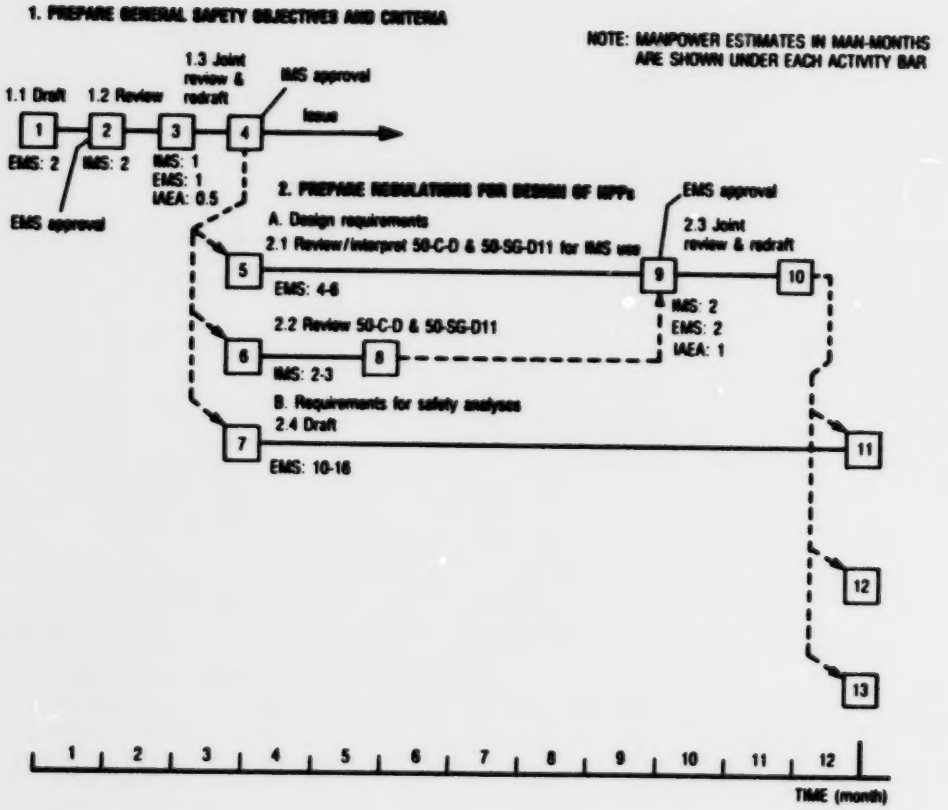

FIGURE 3 PHASE II — FLOWCHART OF ACTIVITIES FOR THE WORKING GROUPS

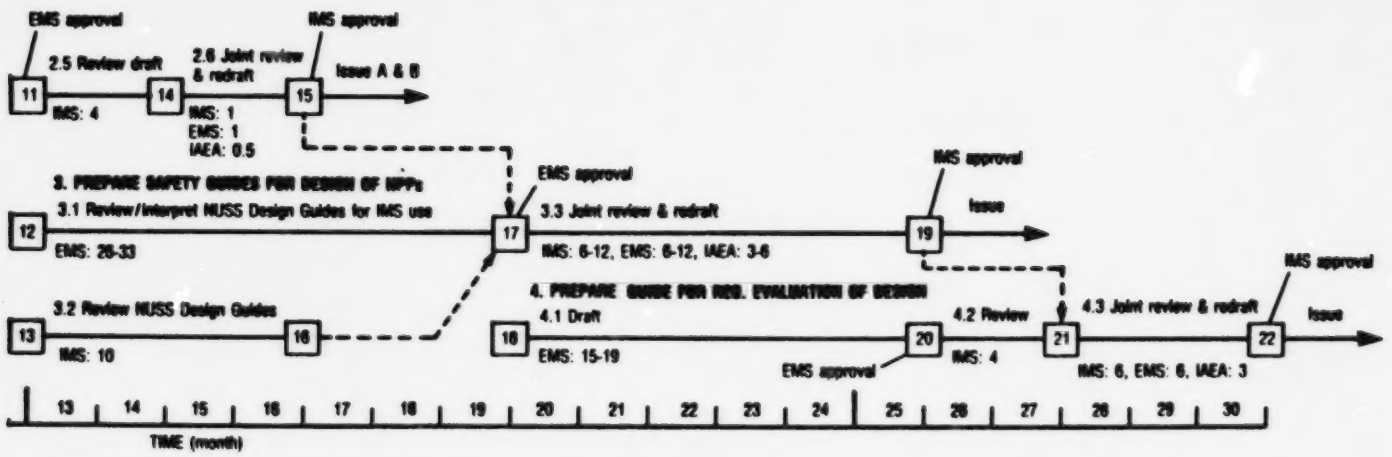

FIGURE 3 cont'd